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Design of Timer Shaped Microstrip-Fed Antenna for RFID Applications

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Abstract- In this research work, a timer shaped patch antenna based on microstrip-fed is designed and presented. In this antenna design an inverted U-shaped slot is embedded into patch. The research, simulation and design of dual band antenna operates at dual band frequencies 2.45 GHz and 5.8 GHz. The fundamental parameters such as return loss, VSWR, radiation pattern and current distribution are obtained. A parametric study of proposed antenna has been carried out by varying some parameters. Simulation tool, based on method of moments has been used to analyze and optimize the antenna.

Keywords: Radio frequency identification (RFID), Microstrip line, Timer Shaped Patch.

I. Introduction

Radio frequency identification technology (RFID) is a technology for the automatic identification by radio of physical objects such as industrial containers, palettes, individual products and also people [i]. In recent years, RFID has moved from obscurity into mainstream applications that help speed the handling of manufactured goods and materials [ii]. It provides wireless identification as well as tracking capability and is more robust than that of barcode. There are many powerful features that make RFID a more effective and efficient in the automatic identification technology [iii]. An RFID system is generally comprises two components: reader and tag [iv]. The reader, sometimes called the interrogator, is made up of a TX/RX module with one or more antennas. The tag consists of a microchip for storing data and an antenna to transmit stored data. Tags are normally categorized into active and passive types by the presence or absence of an internal power supply [v, vi]. Because the passive tag has no power supply of its own, it obtains energy from the continuous wave (CW) signal transmitted by a reader. In other words, the data transmission from tags to the reader is done by reflecting the wave energy back to the reader [v]. RFID readers convert the radio waves sent from the tags to get the digital data and send the collected data to the host computer. The present RFID systems are applied at LF (135 kHz), HF (13.56MHz), UHF (860-960) and microwave bands (2.45 & 5.8 GHz) and the antenna design has been focused on these frequency bands [vii].

A dual‐band antenna RFID tag is presented in [viii] that allow operation in the 900 MHz band as well as in the 2.45GHz band. A dipole antenna with rectangular fractal shaped radiator element is presented in [ix] which operate at UHF (860MHz-960MHz) band and microwave (2.45GHz) band. Several papers have been published on RFID antennas for both active and passive tags including covered slot antenna design [x], L-shaped dielectric resonator antenna design [xi], compact printed monopole antenna [xii], curved dual band antenna [xiii] etc.
In this paper, timer shaped patch antenna with inverted U-shaped slot is presented which covers 2.45 GHz, 5.8GHz which is the operating band of RFID application. The details of the proposed antenna design and the simulated results are presented and discussed next.

II. Antenna Design

A timer shaped patch antenna which is formed by joining of two triangular shaped patches that are connected with back to back is designed for the RFID (2.45 and 5.8 GHz) frequency range and placed on a conventional ground plane. The geometry of the proposed antenna is shown in Fig. 1. The total size of the proposed antenna is 25 mm x 35 mm^2. As shown in fig., the antenna consists of timer shaped patch embedded with an inverted U-shaped slot. The antenna is mainly constructed with the above described patch and fed by microstrip feeding. The total size of this antenna with ground plane is 29 mm x 35 mm x 1.6 mm. The ground plane is symmetrical at the base line of the feeding strip line. The size of timer shaped patch is adjusted to obtain optimum bandwidth. To obtain the optimal parameters of the proposed antenna for RFID application, IE3D, full-wave commercial EM software that can simulate a finite substrate and a finite ground structure, is used. By properly adjusting the dimension of antenna and feeding structure the characteristics of the proposed antenna is improved. Fig. 1 shows the geometry of proposed antenna in which (a) part presents the complete geometry and (b) part presents the back view that is ground of the microstrip patch antenna.

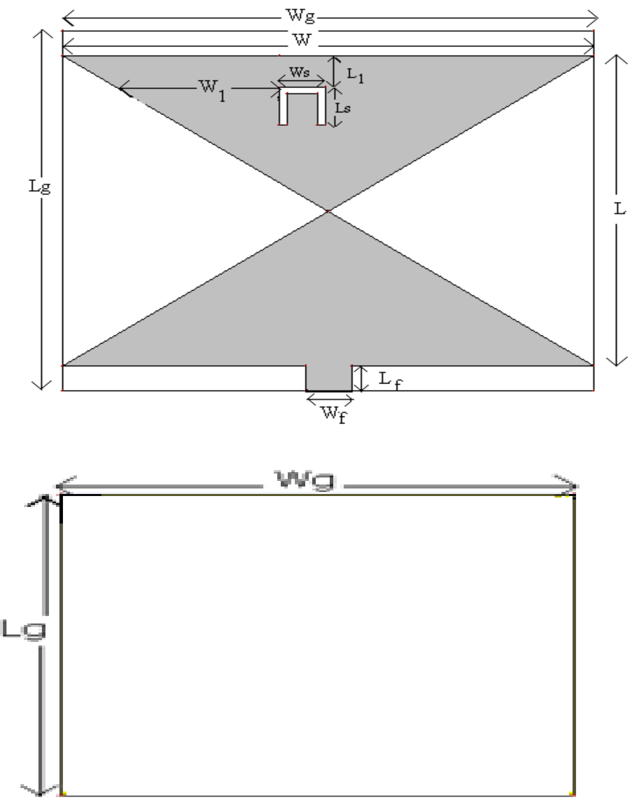

Fig. 1: (a) Geometry of proposed dual band antenna
(b) Back View

The optimized dimensions of antenna are set as follows:

Table 1: Parameters of the proposed dual band antenna

Parameter	Dimensions
L	25
W	35
L_f	2
W_f	3
L_g	29
W_g	35
L_1	2.525
W_1	10.775
L_s	3
W_s	2

The feeding is provided by the rectangular strip of dimensions 2 x 3 mm^2 in the proposed antenna. In the timer shaped patch of antenna, an inverted U-shape is embedded as slot. With the aid of simulation by IE3D Simulator which is based on the method of moment (MOM), the antenna is optimized. The details of simulated performance are described briefly in next section.

III. Simulation Results and Discussions

The design evolution of the proposed antenna and its corresponding simulated return losses are presented in Fig. 2. It shows the simulated results of the proposed optimised antenna, which are in a good agreement. The lower band has a -10 dB impedance bandwidth of 450 MHz (2.32-2.77 GHz) for the simulated results. For the upper band the simulated results provide 640 MHz (5.40-6.04 GHz) bandwidth.

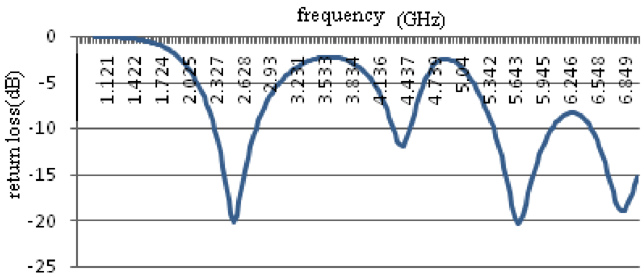

Fig. 2: Return loss of proposed dual band antenna

It has been examined that proposed design covers the dual RFID band from 2.32-2.77GHz and 5.40-6.04GHz.

Fig 3 shows the VSWR of proposed dual band antenna. VSWR of 1.21 is obtained at 5.68 GHz and 1.22 is obtained at 2.53 GHz.

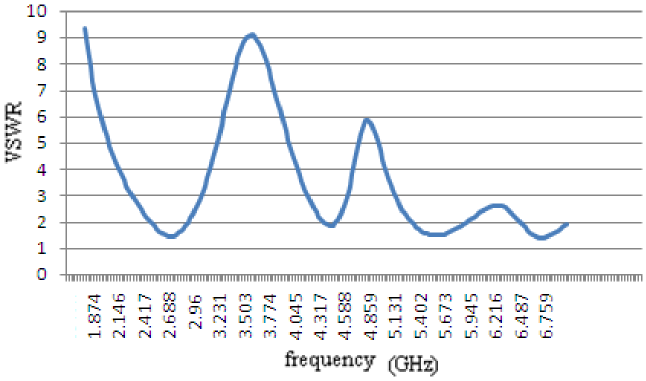

Fig 3: VSWR of proposed dual band antenna

Fig 4(a) and 4(b) show the current distribution pattern at 5.68 GHz and 2.53 GHz frequencies. Maximum current in the proposed antenna is 19.959 (A/m) at 5.68 GHz and 30.54(A/m) at 2.53 GHz. The 3D current distribution plot gives the relationship between the co-polarization (desired) and cross-polarization (undesired) components. It gives a clear picture as to the nature of polarization of the fields propagating through the patch antenna.

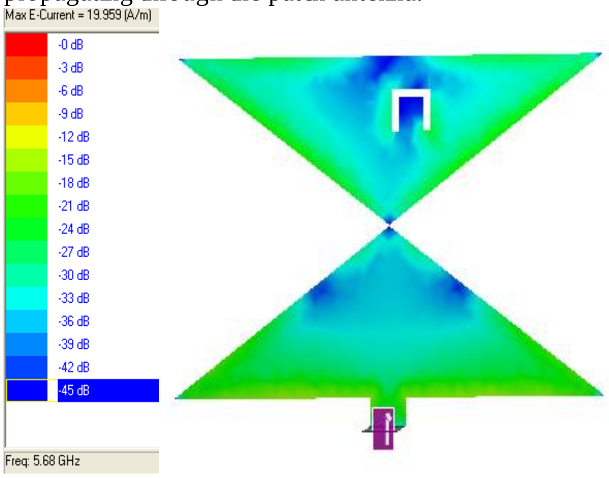

Fig 4(a): Current Distribution of proposed dual band antenna at 5.68 GHz

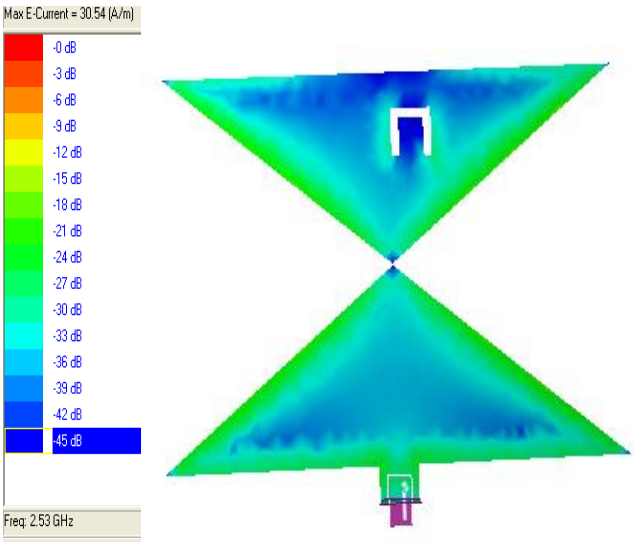

Fig 4(b): Current Distribution of proposed dual band antenna at 2.53 GHz

In fig. 5(a) and 5(b) simulated 2D radiation pattern for elevation and azimuthal plane at resonant frequency 5.68GHz is shown. In fig. 6(a) and 6(b) simulated 2D radiation pattern for elevation and azimuthal plane at resonant frequency 2.53GHz is shown. These patterns are desirable for RFID applications. Radiation pattern presents the graphical representation of radiation properties of antenna as a function of space co-ordinates .Three dimensional radiation pattern is obtained by combining elevation pattern and azimuth pattern.

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Fig. 7 shows three dimensional radiation pattern of proposed antenna.

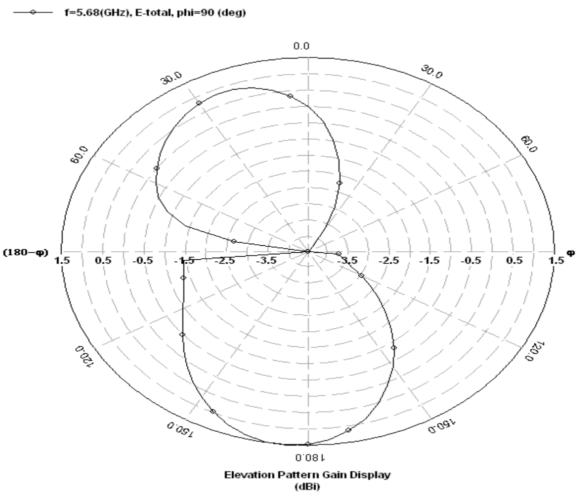

Fig. 5(a): Elevation pattern at 5.68 GHz

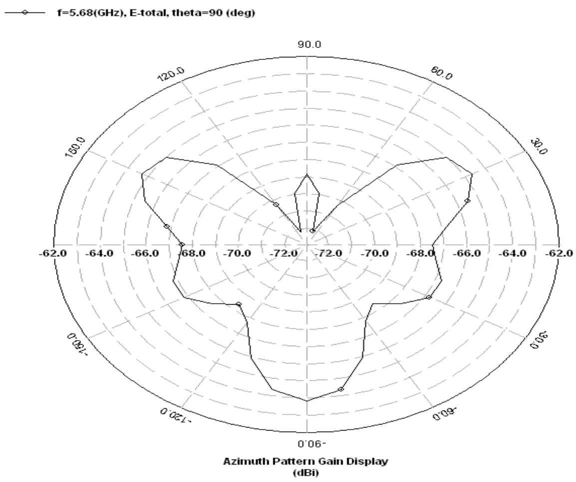

Fig. 5(b): Azimuth pattern at 5.68 GHz

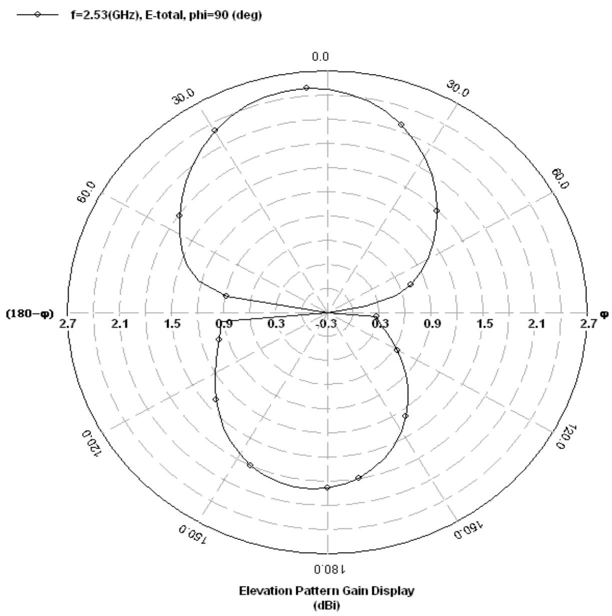

Fig. 6(a): Elevation pattern at 2.53 GHz

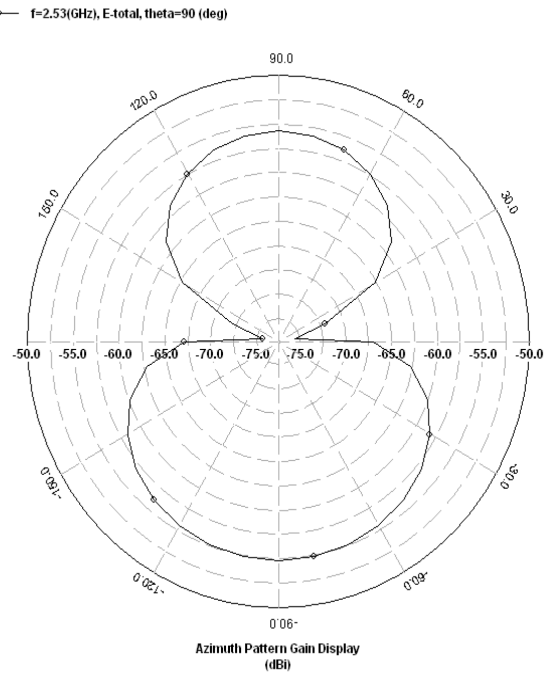

Fig. 6(b): Azimuth pattern at 2.53 GHz

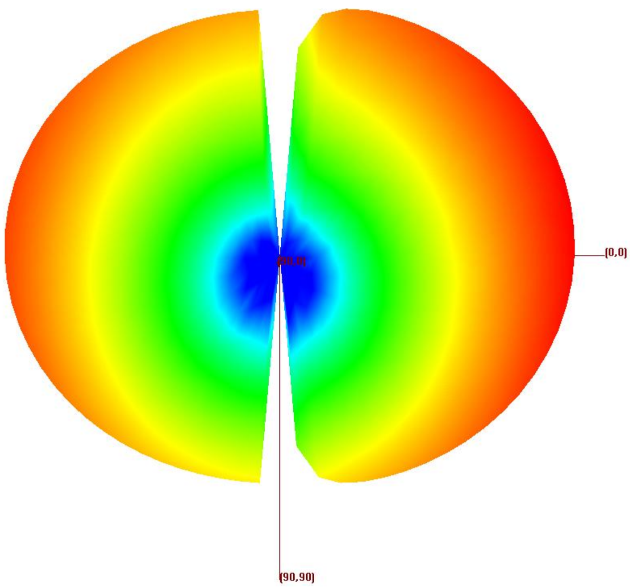

Fig.7: 3-Dimensional Pattern of Proposed Antenna

IV. Parametric Study

Fig. 8 shows the design evolution of the proposed antenna. The following analysis is based on the basic antenna structure (Antenna I) shown in Fig. 8.1, which consists of a single triangular patch and a rectangular ground plane. As shown in Fig. 8.2, a dual-resonant response is obtained by adding another inverted triangular patch on the top of above described patch. As shown in Fig. 8.3, the desired dual-resonant response is obtained by etching an inverted U-shaped slot in timer shaped patch. By adjusting the lengths of the timer shaped patch and inverted U-shaped slot, the desired results can be obtained. Fig.9 shows its corresponding simulated return loss results obtained.

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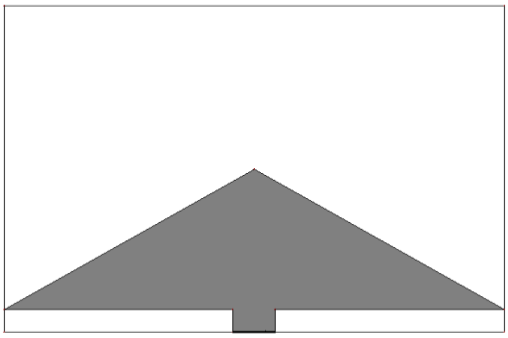

Fig.8.1: Antenna 1

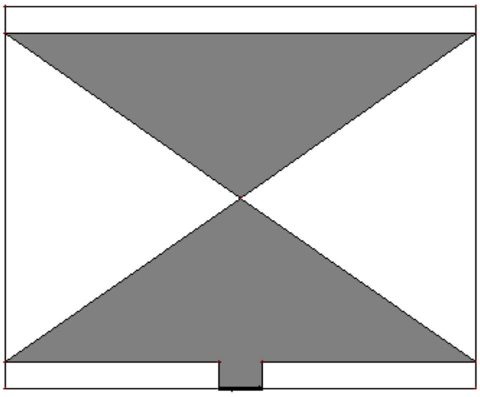

Fig.8.2: Antenna 2

A parametric study has been carried out and it demonstrates that many parameters affect the performance of the proposed antenna. The parametric study is carried out by simulating the antenna with one geometry parameter slightly changed from the reference design while all the other parameters are fixed.

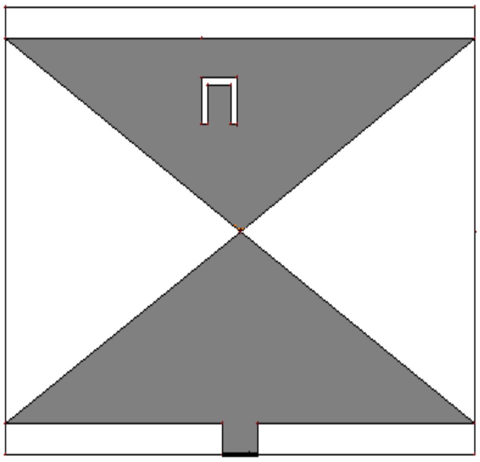

Fig.8.3: Proposed Antenna

Fig. 8: Design evolution of the proposed antenna

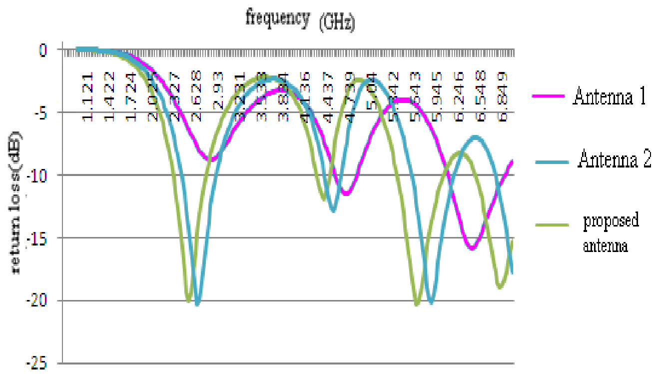

Fig. 9: Corresponding simulated return loss resul

4.1 Effect of Variation of 'W' on Antenna Performance:

Fig.10 showing the case when width of patch changed, there was no impedance bandwidth in working bands. The variation of width has a greater effect on the antenna performance. It can be seen, as we decrease 'W' from optimized value, the return loss in dB (-ve) will decrease at 5.8 GHz and finally lost if we further decrease the value of 'W'. Thus the variation of 'W' has a greater effect on the antenna performance.

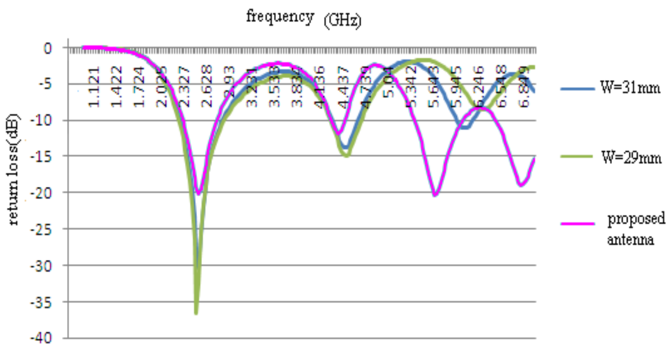

Fig.10: Return loss (S11) of the antenna for different values of W.

4.2 Effect of Variation of 'L_f' on Antenna Performance:

Fig.11 showing the case when L_f slightly changed from the reference design, then there was no impedance bandwidth in working bands. It can be seen, as we increase L_f, the return loss in dB (-ve) will decrease.

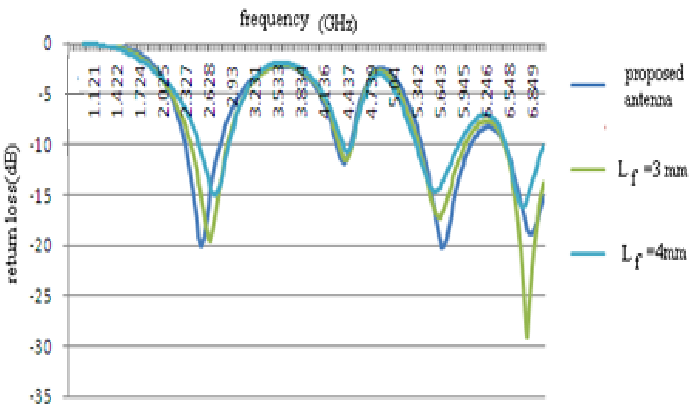

Fig.11: Return loss (S11) of the antenna for different values of L_f

V. Conclusion

A design of dual-band microstrip fed antenna for RFID tag applications has been proposed. With embedding an inverted U-shaped slot, two desired impedance bands are obtained. The effects of varying dimensions of key structure parameters on the antenna performance are studied. A dual band operation has been obtained and good radiation characteristics have been observed at both frequencies. The proposed antenna has been designed and simulated for resonant frequencies at 2.53 GHz and 5.68GHz. These characteristics are very attractive for some wireless communication systems for a variety of applications.

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